IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT:	James M. Halek, et al.		
SERIAL NO.:	10/619,011	EXAMINER:	M. Wimer
FILING DATE:	July 14, 2003	GROUP ART UNIT:	2828
RE:	Microwave Demulsification of Hydrocarbon Emulsion		

DECLARATION OF CHANG-YUL CHA UNDER 37 C.F.R. § 1.132

I, the undersigned Chang-Yul Cha, hereby declare as follows:

1. That I am a citizen of the United States and reside at 3807 Reynolds Street, Laramie, Wyoming, 82072.

2. That I am the founder and president of CHA Corporation. I have also served as a Professor of Chemical and Petroleum Engineering at the University of Wyoming, from which I have recently retired. I have worked in the academic world for over 10 years and also have more than 15 years of industrial experience in scientific research, process development, and project management.

3. That during my career, I have served as vice-president for Parahoe and SAI Corporations, as research manager for the Western Research Institute, and for Occidental Petroleum, as well as a consultant to the United Nations.

4. That I have authored over 100 publications in oil shale, coal, tar sands, flue gas cleanup, and microwave induced chemical reactions. I have received the T.P. Hoar Prize from Corrosion Science (1981) and the outstanding paper award from the International Energy and Environmental Conference (1983). In 1998, I also received the Tibbetts Award from the United States Small Business Administration. That same year, I also became an honorable member of the American Inventor Association. I am a named inventor of 54 patents and a pending published United States patent application in fields such as coal upgrading, oil shale and tar sand recovery, flue gas cleanup, microwave induced chemical reactions, and waste recycle processes. Lists of these United States

patents and the published United States patent application are provided as Exhibits B and C, respectively.

5. That since the founding of CHA Corporation in 1989, the company has completed multiple projects funded by both the government and private industry. Since its formation, CHA Corporation has focused almost exclusively on the research and development of technologies associated with using microwave radiation to decontaminate water that is contaminated with hydrocarbons. As a particular example, the company is currently researching and developing technology for decontaminating water produced by washing vehicles in combat areas, which water may contain hydrocarbons as well as chemical or biological agents.

6. That I have reviewed United States patent application Serial Number 10/619,011 (hereinafter referred to as "the '011 application") entitled MICROWAVE DEMULSIFICATION OF HYDROCARBON EMULSION with named inventors James M. Halek, et al. (hereinafter collectively referred to as "Applicant") and have reviewed the claims of the '011 application defining the invention (hereinafter referred to as "the claimed invention") as set forth in the attached Exhibit A. I understand that the listing of claims in Exhibit A represents the status of the claims, assuming that the submitted amendment is entered.

7. That, as explained below, the invention disclosed in the '011 application provides a demulsification system to facilitate recovery of hydrocarbons, such as petroleum products, from a liquid or solid substrate by using microwave energy to energize and separate molecular bonds between the hydrocarbons and the substrate. In this way, the invention disclosed in the '011 application solves the problem of demulsifying a hydrocarbon emulsion safely and effectively, a problem that has confronted the industry for many years.

8. That my long employment and extensive experience with CHA Corporation as set forth above allow me to assess the importance and nonobviousness of Applicant's claimed invention.

9. That for many years prior to the filing of the '011 application, hydrocarbons have been extracted from underground media, such as oil shale,

tar sand, and ground water contamination, using a variety of techniques, including heat and chemical treatment. As is well known in the art, heating the petroleum products reduces their viscosity, facilitating extraction from the medium. Various techniques have been proposed for heating the petroleum products. For instance, a geologic formation can be heated via electrodes deployed in the ground using resistance heating. As an alternative, the geologic formation can be heated by steam that is either delivered to the geologic formation or formed within the geologic formation.

10. That microwave energy can also be used to generate heat for extracting petroleum products from an underground medium. Generally, microwave techniques use an elongate antenna that is located below ground level, typically within a borehole, at the site where heating is desired. A radio frequency (RF) generator, such as a magnetron or a klystron generator, generates an RF signal, which typically contains microwave energy. A coaxial transmission line or other waveguide transmits the RF signal from the RF generator to the antenna, which radiates the RF signal to the surrounding environment, *i.e.*, the underground medium.

11. That the use of microwave energy to heat and remove hydrocarbons from other environments, such as oil-based emulsions, has also been proposed. For example, in some conventional techniques, a hydrocarbon and water emulsion flows through a microwave cavity having emulsion flow chambers. These chambers, in combination with a microwave waveguide, form a resonant chamber within which microwave energy reflects to treat the flowing emulsion.

12. That certain of these conventional approaches are characterized by certain drawbacks that limit the effectiveness of those approaches. For example, the heat generated in the process may be sufficient to ignite nearby materials, such as explosive gas byproducts or the hydrocarbons themselves. As a result, cooling systems or explosion suppression systems are often required to reduce the likelihood of explosion. One technique to suppress ignition and reduce the likelihood of explosion is disclosed in U.S. Patent No. 5,829,528, issued

November 3, 1998 to Uthe, entitled IGNITION SUPPRESSION SYSTEM FOR DOWN HOLE ANTENNAS. In addition, the danger of igniting nearby materials is a significant constraint on the amount of energy that can be delivered safely to the emulsion.

13. That, in approaches in which microwave energy is emitted from a source above the emulsion, the microwave energy often does not penetrate adequately deeply to treat the entire emulsion. Only a portion of the emulsion, such as a surface layer, is heated effectively, potentially resulting in inefficient demulsification. As a result, a substantial portion of the emulsion is demulsified to only a slight degree, if at all. In this portion, much of the hydrocarbons present are not extracted.

14. That, even in approaches in which microwave energy is applied via an antenna inserted in a borehole, many antennas do not radiate the microwave energy effectively. As a result, such antennas typically consume relatively large amounts of power, leading to high costs. In addition, a substantial portion of the microwave energy not radiated is internally reflected within the antenna, potentially resulting in heating of the antenna itself and an elevated risk of combustion.

15. That, in the demulsification system disclosed in the '011 application, microwave energy is applied to an emulsion containing a substrate, such as water, and a hydrocarbon. The hydrocarbon molecules and water molecules have different absorptive properties with respect to photons that carry the applied microwave energy. Each type of molecule has a range of frequencies it will absorb and emit based on the atoms included in the molecule and the types of bonding occurring within the molecule. In the case of hydrocarbon molecules, which are considerably more complex than water molecules, the absorption spectrum substantially coincides with the frequency of the applied RF energy, which is disclosed in the '011 application as approximately 915 MHz.

16. That, in the demulsification system disclosed in the '011 application, when a hydrocarbon molecule absorbs a photon, the electrons in the

hydrocarbon molecule absorb the energy carried by the photon and move to a higher energy level. The electrons then emit a photon and return to their previous energy levels. The hydrocarbon molecule absorbs sufficient energy to break weak bonds within the hydrocarbon molecule, thereby changing the specific gravity of the hydrocarbon molecule. Further, the energy imparted may be sufficient to break weak bonds between the hydrocarbon molecule and a substrate molecule to which it may be attached, allowing the hydrocarbon molecule to migrate.

17. That, in the demulsification system disclosed in the '011 application, when energy is imparted to the hydrocarbon molecules, they migrate randomly. Over time, the hydrocarbon molecules tend to migrate away from the microwave applicator used to apply the microwave energy. The migration process continues until the hydrocarbon molecules randomly find their way to an outlet, such as a pumping well, and are removed or are trapped, for example, by a vacuum system. The only molecules that will not eventually be trapped by this system are molecules that are too far from the microwave applicator to absorb the necessary photons. With 75 kW of energy applied, for example, hydrocarbon molecules up to approximately 1700 feet away from the microwave applicator can absorb sufficient energy to effect migration. In practical terms, this means that the effective range of demulsification is significantly increased relative to conventional heating-based approaches.

18. That I believe people having ordinary skill in the art are primarily the engineers employed by companies involved in the recovery of hydrocarbons and the engineers employed by companies involved in the manufacture of hydrocarbon recovery systems. These personnel are involved in designing and testing such systems, including, for example, the antennas used to transmit the microwave energy into treatment volumes.

19. That I have reviewed and considered United States patent 5,914,014 to Kartchner and United States patent 6,583,394 to Araya et al., and that I have considered the extent to which these patents would lead me and others of ordinary skill in the pertinent art to the claimed invention of Applicant.

20. That I verily believe that the Araya et al. patent is of little relevance or assistance in leading one of ordinary skill in the pertinent art to the claimed invention. This is so because the Araya et al. disclosure would be perceived by those of ordinary skill in the art as being applicable to the processing of ceramics. In particular, the Araya et al. disclosure would be perceived as relating to processing a ceramic material by placing it in a microwave heating apparatus having a microwave cavity and subjecting the ceramic material to a combination of microwave radiation and conventional heat. The Araya et al. patent has no teaching concerning demulsification of hydrocarbon emulsions.

21. That Applicant's invention, as defined in claims 20-70, uses a radio frequency applicator positioned within a containment structure or other treatment volume to deliver microwave energy to the treatment volume. The RF applicator includes an antenna body having a longitudinal axis and an outer surface defining slots substantially parallel to one another and substantially perpendicular to the longitudinal axis. When the RF applicator delivers the microwave energy into the treatment volume, the microwave-absorptive material and the substrate are separated from one another because the microwave-absorptive material absorbs the microwave energy, causing weak molecular bonds within the microwave-absorptive material to be broken. As a result, the specific gravity of the microwave-absorptive material is changed. In addition, weak bonds between the microwave-absorptive material and a substrate to which it may be attached may be broken. Due to the altered specific gravity of the microwave-absorptive material and the potential breaking of the bonds between the microwave-absorptive material and the substrate, the molecules of the microwave-absorptive material begin to migrate in a random fashion. While the migration of individual molecules is random, the trend is to migrate away from the RF applicator. This trend may be exploited to cause the microwave-absorptive material to, over a period of time, migrate toward an outlet, such as a pumping well. A vacuum system or other extraction system can then be used to extract the microwave-absorptive material, which is at this point separated from the substrate.

22. That, as the emulsion is demulsified, it separates into layers or strata according to the specific gravities of the components of the emulsion. Components having relatively low specific gravities, such as hydrocarbons, occupy strata closest to the surface of the emulsion. Conversely, components having higher specific gravities, such as water and other substrates, occupy lower strata. The components having the highest specific gravities, such as solids, settle to the bottom of the contained treatment volume. The duration of the application of microwave energy depends on a number of considerations, including, for example, the nature of the emulsion, and the power level of the microwave energy. As an illustrative example, the contents of a standard "frak" type tank may be demulsified within 4-12 hours with an applied power of 30 kW, depending on the complexity of the emulsion.

23. That using an RF applicator with slots formed horizontally, rather than vertically as in some conventional antennas, enables the RF applicator to radiate substantially all of the microwave energy into the contained treatment volume. By contrast, some conventional antennas exhibit internal reflection of the microwave energy. Such internal reflection may have a number of adverse effects. Reflection of microwave energy within an antenna potentially results in undesirable heating of the antenna, increasing the risk of igniting materials in the environment, such as explosive gases. In addition, microwave energy that is converted to heat within the antenna in this way is not radiated into the treatment volume and is essentially wasted. By substantially eliminating internal reflection of microwave energy, the RF applicator generates significantly less heat relative to some conventional microwave antennas. Further advantageously, the RF applicator radiates substantially all of the energy into the treatment volume, significantly improving the energy efficiency of the process.

24. That, in the demulsification system disclosed in the '011 application, using an RF applicator having the slot configuration disclosed therein facilitates radiation of microwave energy over approximately a 135° arc outward from each group of slots, *i.e.*, from each of the two parallel faces having slots formed thereon. Accordingly, the RF applicator radiates microwave energy over

an approximately 270° range. Limiting the radiation to this range substantially eliminates destructive interference between the microwaves, resulting in a relatively uniform radiation pattern over the approximately 270° range.

25. That, in the demulsification system disclosed in the '011 application, the horizontal slots are of a non-uniform size. In particular, generally speaking, the sizes of the slots increase with increasing distance from the RF generator. The field strength generated by the RF generator is attenuated as the distance from the RF generator increases. The energy radiated from a particular slot is a function of the field strength at the location of the slot and of the size of the slot, and is related to the product of the field strength and the slot size. Using slots whose sizes increase as the distance from the RF generator increases, that is, as the field strength decreases, causes the total energy emitted by the slots to be substantially equal along the length of the antenna body. Thus, the design of the antenna body as disclosed in the '011 application and as claimed in claims 20-70 promotes a more even distribution of microwave energy than conventional designs. In marked contrast, the Araya et al. patent admits that "the waveguide arrangements of FIGS. 3 and 4 do not provide the uniformity of microwave power distribution required to minimize ceramic piece distortion and/or cracking at the microwave input power levels necessary for the effective firing of ceramic products such as thin-walled ceramic honeycomb structures." See column 7, lines 11-16.

26. From my experience, if the invention of claims 20-70 were obvious to engineers employed by companies involved in the recovery of hydrocarbons or by companies involved in the manufacture of hydrocarbon recovery systems, I believe that this badly needed invention would have been invented long ago and in wide use. I verily believe that the claimed invention of claims 20-70 is not known in and is not obvious from the existing knowledge in the field of the invention, is not shown or obvious from the Kartchner patent or from any combining of that existing knowledge with the Araya et al. patent. I believe that in its totality, the invention of claims 20-70 is a highly significant advance in the

field of hydrocarbon recovery and promotes the safe and efficient remediation of hydrocarbon emulsions.

27. I declare under penalty of perjury that the foregoing is true and correct. I am aware that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. §1001 and may jeopardize the validity of the application or any patent issuing thereon. All statements made of my own knowledge are true and that all statements made on information and belief are believed to be true.

January 2, 2007
DATE

CHANG-YUL CHA

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EXHIBIT A

CLAIMS IN APPLICATION AS OF JANUARY 3, 2007

1. (Withdrawn) A radio frequency (RF) applicator comprising an antenna body having a longitudinal axis and an outer surface defining a plurality of slots substantially parallel to one another and substantially perpendicular to the longitudinal axis.

2. (Withdrawn) The RF applicator of claim 1, wherein the antenna body is tapered along the longitudinal axis.

3. (Withdrawn) The RF applicator of claim 1, wherein:

the antenna body has a length; and

the outer surface defines the plurality of slots along substantially the entire length of the antenna body.

4. (Withdrawn) The RF applicator of claim 1, wherein the antenna body comprises a plurality of faces forming a quadrilateral cross-section.

5. (Withdrawn) The RF applicator of claim 4, wherein the slots are defined by each of two parallel faces.

6. (Withdrawn) The RF applicator of claim 4, wherein the plurality of faces form a rectangular cross-section.

7. (Withdrawn) The RF applicator of claim 1, wherein the antenna body comprises two walls formed from an RF opaque material.

8. (Withdrawn) The RF applicator of claim 1, wherein the walls are formed from aluminum.

9. (Withdrawn) The RF applicator of claim 1, wherein the antenna body is formed from aluminum.

10. (Withdrawn) The RF applicator of claim 1, further comprising:

an RF transparent window arrangement disposed proximate the outer surface of the antenna body and arranged to cover the plurality of slots; and

an antenna enclosure formed proximate the antenna body to substantially seal the antenna body from an environment external to the RF applicator.

11. (Withdrawn) The RF applicator of claim 10, wherein the RF transparent window arrangement comprises a plurality of RF transparent windows formed from a material having a low dielectric constant.

12. (Withdrawn) The RF applicator of claim 11, wherein the RF transparent windows are formed from a material selected from the group consisting of fiberglass and TEFLON® polytetrafluoroethylene.

13. (Withdrawn) The RF applicator of claim 10, wherein the antenna enclosure is formed from a material having a low dielectric constant.

14. (Withdrawn) The RF applicator of claim 13, wherein the antenna enclosure is formed from a material having a similar dielectric constant relative to a material forming the RF transparent window arrangement.

15. (Withdrawn) The RF applicator of claim 13, wherein the antenna enclosure is formed from fiberglass.

16. (Withdrawn) The RF applicator of claim 1, wherein:

the antenna body comprises first and second ends; and

a waveguide is coupled to the first end of the antenna body.

17. (Withdrawn) The RF applicator of claim 16, further comprising a cap coupled to the second end of the antenna body.

18. (Withdrawn) The RF applicator of claim 17, wherein the cap is arranged to reflect an RF signal propagated within the antenna body to generate constructive interference.

19. (Withdrawn) The RF applicator of claim 16, wherein the cap is formed from aluminum.

20. (Currently Amended) A demulsification arrangement <u>usable with a power source</u> to remove a microwave-absorptive material from a substrate, the demulsification arrangement comprising:

a containment structure defining a treatment volume and adaptable to receive an emulsion comprising the microwave-absorptive material and the substrate;

a radio frequency (RF) generator connectable to the power source and configured to generate an RF signal; and

an RF ~~a radio frequency (RF)~~ applicator operatively coupled to the RF generator ~~power source~~ and positionable ~~positioned~~ within the containment structure to deliver microwave energy into the treatment volume, the RF applicator comprising an antenna body having a longitudinal axis and a length and an outer surface defining a plurality of slots ~~substantially parallel to one another and~~ substantially perpendicular to the longitudinal axis and non-uniform in size ~~and arranged so as to radiate the microwave energy over substantially less than a 360° arc outward from the RF applicator~~;

whereby, when the containment structure contains the emulsion and the RF applicator delivers the microwave energy into the treatment volume, the microwave-absorptive material and the substrate are demulsified.

21. (Original) The demulsification arrangement of claim 20, wherein the antenna body is tapered along the longitudinal axis.

22. (Currently Amended) The demulsification arrangement of claim 20, wherein~~:~~

the antenna body has a first end that is proximate to the RF applicator and a second end that is distal from the RF applicator, and wherein the antenna body has a first cross-sectional area at the first end and a second cross-sectional area, smaller than the first cross-sectional area, at the second end ~~length; and~~

~~the outer surface defines the plurality of slots along substantially the entire length of the antenna body~~.

23. (Currently Amended) The demulsification arrangement of claim 20, wherein the antenna body comprises a plurality of walls ~~faces~~ forming a rectangular cross-section.

24. (Original) The demulsification arrangement of claim 23, wherein the slots are defined by each of two parallel walls ~~faces~~.

25. (Original) The demulsification arrangement of claim 20, wherein the antenna body comprises two walls formed from an RF opaque material.

26. (Original) The demulsification arrangement of claim 25, wherein the walls are formed from aluminum.

27. (Currently Amended) The demulsification arrangement of claim 20, wherein the RF applicator further comprises an RF transparent antenna enclosure formed proximate the antenna body to substantially seal the antenna body from an environment external to the RF applicator ~~is formed from aluminum~~.

28. (Currently Amended) The demulsification arrangement of claim 20, wherein the RF applicator further comprises~~:~~

an RF transparent window arrangement disposed proximate the outer surface of the antenna body and arranged to cover the plurality of slots~~; and~~

~~an antenna enclosure formed proximate the antenna body to substantially seal the antenna body from an environment external to the RF applicator~~.

29. (Original) The demulsification arrangement of claim 28, wherein the RF transparent window arrangement comprises a plurality of RF transparent windows formed from a material having a low dielectric constant.

30. (Original) The demulsification arrangement of claim 29, wherein the RF transparent windows are formed from a material selected from the group consisting of fiberglass and TEFLON® polytetrafluoroethylene.

31. (Currently Amended) The demulsification arrangement of claim 27 ~~28~~, wherein the antenna enclosure is formed from a material having a low dielectric constant.

32. (Currently Amended) The demulsification arrangement of claim 20 ~~31~~, wherein at least some of the slots have sizes that increase with increasing distance from the RF generator ~~the antenna enclosure is formed from a material having a similar dielectric constant relative to a material forming the RF transparent window arrangement~~.

33. (Original) The demulsification arrangement of claim 31, wherein the antenna enclosure is formed from fiberglass.

34. (Currently Amended) The demulsification arrangement of claim 20, wherein~~:~~

the slots are substantially uniformly spaced apart from one another along the length of the antenna body ~~comprises first and second ends; and~~

~~a waveguide is coupled to the first end of the antenna body~~.

35. (Currently Amended) The demulsification arrangement of claim <u>20</u> ~~34~~, wherein the RF applicator further comprises a cap coupled to <u>an</u> ~~the second~~ end of the antenna body <u>located distally from the RF generator</u>.

36. (Original) The demulsification arrangement of claim 35, wherein the cap is arranged to reflect an RF signal propagated within the antenna body to generate constructive interference.

37. (Original) The demulsification arrangement of claim 35, wherein the cap is formed from aluminum.

38. (Currently Amended) The demulsification arrangement of claim 20, ~~further comprising an RF generator operatively coupled to~~ <u>wherein</u> the antenna body <u>comprises first and second faces that are spaced apart from one another and in which the slots are formed, the slots being arranged so as to radiate</u> ~~and to the power source and configured to generate~~ the microwave energy <u>over substantially less than a 360° arc outward from the RF applicator</u>.

39. (Currently Amended) The demulsification arrangement of claim <u>20</u> ~~38~~, further comprising a control arrangement operatively coupled to the RF generator.

40. (Original) The demulsification arrangement of claim 20, further comprising an outlet port formed on the container.

41. (Original) The demulsification arrangement of claim 20, wherein the microwave-absorptive material comprises a hydrocarbon.

42. (Original) The demulsification arrangement of claim 20, wherein the substrate comprises water.

43. (Currently Amended) A demulsification arrangement usable with a power source, the demulsification arrangement comprising:

~~a power source;~~

a radio frequency (RF) generator connectable ~~operatively coupled~~ to the power source and configured to generate an RF signal;

a control arrangement configured to be operatively coupled to the RF generator to control generation of the RF signal; and

a radio frequency (RF) applicator ~~configured to be~~ operatively coupled to the RF generator, the RF applicator being positionable ~~positioned~~ within a treatment volume containing an emulsion comprising a microwave-absorptive material and a substrate ~~to transmit the RF signal~~, the RF applicator comprising an antenna body having a longitudinal axis and a length and an outer surface defining a plurality of slots ~~substantially parallel to one another and~~ substantially perpendicular to the longitudinal axis and non-uniform in size ~~and arranged so as to radiate the microwave energy over substantially less than a 360° arc outward from the RF applicator~~;

whereby, when the control arrangement, the RF applicator, and the RF generator are operatively coupled and the RF applicator transmits the RF signal into the treatment volume, the microwave-absorptive material and the substrate are demulsified.

44. (Original) The demulsification arrangement of claim 43, wherein the antenna body is tapered along the longitudinal axis.

45. (Currently Amended) The demulsification arrangement of claim 43, wherein~~:~~

the antenna body has a first end that is proximate to the RF applicator and a second end that is distal from the RF applicator, and wherein the antenna body has a first cross-sectional area at the first end and a second cross-sectional area, smaller than the first cross-sectional area, at the second end ~~length; and~~

~~the outer surface defines the plurality of slots along substantially the entire length of the antenna body~~.

46. (Currently Amended) The demulsification arrangement of claim 43, wherein the antenna body comprises a plurality of walls ~~faces~~ forming a rectangular cross-section.

47. (Currently Amended) The demulsification arrangement of claim 46, wherein the slots are defined by each of two parallel walls ~~faces~~.

48. (Original) The demulsification arrangement of claim 43, wherein the antenna body comprises two walls formed from an RF opaque material.

49. (Original) The demulsification arrangement of claim 48, wherein the walls are formed from aluminum.

50. (Currently Amended) The demulsification arrangement of claim 43, wherein the RF applicator further comprises an RF transparent antenna enclosure formed proximate the antenna body to substantially seal the antenna body from an environment external to the RF applicator ~~is formed from aluminum~~.

51. (Currently Amended) The demulsification arrangement of claim 43, wherein the RF applicator further comprises:

an RF transparent window arrangement disposed proximate the outer surface of the antenna body and arranged to cover the plurality of slots~~; and~~

~~an antenna enclosure formed proximate the antenna body to substantially seal the antenna body from an environment external to the RF applicator~~.

52. (Original) The demulsification arrangement of claim 51, wherein the RF transparent window arrangement comprises a plurality of RF transparent windows formed from a material having a low dielectric constant.

53. (Original) The demulsification arrangement of claim 52, wherein the RF transparent windows are formed from a material selected from the group consisting of fiberglass and TEFLON® polytetrafluoroethylene.

54. (Currently Amended) The demulsification arrangement of claim 50 ~~51~~, wherein the antenna enclosure is formed from a material having a low dielectric constant.

55. (Currently Amended) The demulsification arrangement of claim 20 ~~54~~, wherein at least some of the slots have sizes that increase with increasing distance from the RF generator ~~the antenna enclosure is formed from a material having a similar dielectric constant relative to a material forming the RF transparent window arrangement~~.

56. (Original) The demulsification arrangement of claim 54, wherein the antenna enclosure is formed from fiberglass.

57. (Currently Amended) The demulsification arrangement of claim 43, wherein~~:~~

the slots are substantially uniformly spaced apart from one another along the length of the antenna body ~~comprises first and second ends; and~~

~~a waveguide is coupled to the first end of the antenna body~~.

58. (Currently Amended) The demulsification arrangement of claim 43 ~~57~~, wherein the RF applicator further comprises a cap coupled to an ~~the second~~ end of the antenna body located distally from the RF generator.

59. (Original) The demulsification arrangement of claim 58, wherein the cap is arranged to reflect an RF signal propagated within the antenna body to generate constructive interference.

60. (Original) The demulsification arrangement of claim 59, wherein the cap is formed from aluminum.

61. (Original) The demulsification arrangement of claim 43, wherein the microwave-absorptive material comprises a hydrocarbon.

62. (Original) The demulsification arrangement of claim 43, wherein the substrate comprises water.

63. (Original) The demulsification arrangement of claim 43, wherein the treatment volume comprises one of an underground treatment volume and an above-ground contained treatment volume.

64. (Original) The demulsification arrangement of claim 63, wherein the above-ground contained treatment volume comprises a container to receive the emulsion, the container having at least one outlet port defined by a wall of the container.

Please add the following new claims:

65. (New) The demulsification arrangement of claim 40, wherein the outlet port is configurable between an untapped configuration while the RF applicator delivers the microwave energy into the treatment volume and a tapped configuration after the emulsion is demulsified.

66. (New) The demulsification arrangement of claim 64, wherein the outlet port is configurable between an untapped configuration while the RF applicator delivers the microwave energy into the treatment volume and a tapped configuration after the emulsion is demulsified.

67. (New) The demulsification arrangement of claim 43, wherein the antenna body comprises first and second faces that are spaced apart from one another and in which the slots are formed, the slots being arranged so as to radiate the microwave energy over substantially less than a 360° arc outward from the RF applicator.

68. (New) A demulsification arrangement usable with a power source to remove a microwave-absorptive material from a substrate, the demulsification arrangement consisting essentially of:

a radio frequency (RF) generator connectable to the power source and configured to generate an RF signal; and

an RF applicator operatively coupled to the RF generator and positionable within a treatment volume containing an emulsion comprising the microwave-absorptive material and the substrate to deliver microwave energy into the treatment volume, the RF applicator comprising an antenna body having a longitudinal axis and a length and an outer surface defining a plurality of slots substantially uniformly spaced apart from one another along the length of the antenna body and non-uniform in size;

whereby, when the containment structure contains the emulsion and the RF applicator delivers the microwave energy into the treatment volume, the microwave-absorptive material and the substrate are demulsified.

69. (New) The demulsification arrangement of claim 68, wherein the slots are substantially perpendicular to the longitudinal axis.

70. (New) The demulsification arrangement of claim 68, wherein at least some of the slots have sizes that increase with increasing distance from the RF generator.

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EXHIBIT B

PATENTS LISTING CHANG-YUL CHA AS SOLE OR JOINT INVENTOR

1. APPARATUS FOR OBTAINING UNIFORM GAS FLOW THROUGH AN IN-SITU OIL SHALE RETORT, U.S. Patent No. 3,941,421, Mar. 2, 1976 with R.S. Burton and R.D. Ridley.

2. PROCESS FOR IN-SITU SHALE RETORTING WITH OFF-GAS RECYCLING, U.S. Patent No. 3,944,343, Nov. 30, 1975 with R.D. Ridley.

3. METHOD OF IGNITING IN-SITU OIL SHALE RETORT WITH FUEL RICH FLUE GAS, U.S. Patent No. 4,005,752, Feb. 1, 1977.

4. ENRICHING OFF-GAS FROM OIL SHALE RETORT, U.S. Patent No. 4,036,299, Jul. 19, 1977 with R.D. Ridley.

5. SYSTEM FOR FUEL AND OIL SHALE RETORT, U.S. Patent No. 4,014,575, Mar. 29, 1977 with G.B. French, R.D. Ridley, and W.J. Bartel.

6. PROCESS FOR RECOVERING CARBONACEOUS VALUES FROM POST IN-SITU OIL SHALE RETORTING, U.S. Patent No. 4,105,072, Aug. 8, 1978.

7. METHOD AND APPARATUS FOR RETORTING OIL SHALE AT SUBATMOSPHERIC PRESSURE, U.S. Patent No. 4,076,312, Feb. 28, 1978 with R.S. Burton and R.D. Ridley.

8. IN-SITU RETORTING WITH WATER VAPORIZED IN-SITU, U.S. Patent No. 4,089,375, May 16, 1978.

9. IN-SITU OIL SHALE RETORTING PROCESS USING AN INTERMEDIATE GAS PLENUM, U.S. Patent No. 4,119,345, Oct. 10, 1978 with W.J. Bartel and R.S. Burton.

10. DECREASING HYDROGEN SULFIDE CONCENTRATION OF A GAS, U.S. Patent No. 4,086,962, May 2, 1978.

11. METHOD OF ENHANCING YIELD FROM AN IN-SITU OIL SHALE RETORT, U.S. Patent No. 4,126,180, Nov. 21, 1978.

12. IN-SITU OIL SHALE RETORT WITH VARIATIONS IN SURFACE AREA CORRESPONDING TO KEROGEN CONTENT OF FORMATION WITHIN RETORT SITE, U.S. Patent No. 4,149,595, Apr. 17, 1979.

13. OPERATION OF AN IN-SITU OIL SHALE RETORT, U.S. Patent No. 4,149,752, Apr., 1979 with R.S. Burton.

14. DETERMINING THE LOCUS OF A RETORTING ZONE IN AN OIL SHALE RETORT BY RATE OF SHALE OIL PRODUCTION, U.S. Patent No. 4,150,722, Apr. 24, 1979 with W.J. Bartel.

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EXHIBIT C

PUBLISHED PATENT APPLICATION LISTING CHANG-YUL CHA AS INVENTOR

1. PROCESS FOR MICROWAVE ALTERNATIVE DESTRUCTION-ADSORPTION, U.S. Patent Application Publication No. 2005/0154248 A1, Jul. 14, 2005.